ROOT AND MICROBIAL CONTRIBUTION TO THE TOTAL CO_2 EFFLUX FROM SOIL AS DEPENDENT ON LAND USE

A. Larionova, V. Lopes de Gerenju, D.Sapronov, I. Yevdokimov

Institute of Physicochemical and BiologicalProblems in Soil Science RAS, Pushchino, Moscow Region, 142290 Russia; ilya@issp.serpukhov.su

ABSTRACT

The contribution of roots to the annual CO_2 emission from gray forest and soddy podzolic soils measured in the field experiments under crops and native vegetation varied in the wide range from 10 to 58% of CO_2 emission from the soil by mean value of 33%. The contribution of roots to the CO_2 emission from soil surface calculated for growth season for all the ecosystems studied was equal to 44%. In agroecosystems the contribution of roots was strongly related to the length of crops growth. CO_2 emission during dormant periods of the year was greatly controlled by the decomposition of surface litter and detritus in the soil than by respiration of roots and soil microorganisms.

INTRODUCTION

Soils are a potential source of atmospheric CO_2, however, total CO_2 efflux from soil do not provide sufficient information to determine whether the soil is a net source or net sink for atmospheric CO_2. Carbon dioxide evolved from soil surface not all produced by the microbial decomposition of soil organic matter. Respiration of plant roots and vegetation-induced changes of soil organic matter turnover contribute considerably to the total CO_2 efflux from soil surface. Hence, the separation of total CO_2 efflux on root (autotrophic) and microbial (heterotrophic) respiration is very important in quantifying soil C source in the atmosphere. Most estimates of root contribution to the total CO_2 efflux were carried out during growth season [*Hansson et al,* 2000], so the year round measurements of root respiration are very useful for calculations of annual C balance in the soil.

MATERIALS AND METHODS

The contribution of roots and soil microorganisms to total CO_2 efflux was investigated in 1980-2000's in forests, grasslands and croplands on soddy-podzolic and gray forest soils in Moscow region (Russia). The share of root and microbial respiration was measured by component integration technique [*Hansson et al.,* 2000; *Larionova et al.,* 1998]. Soil cores (from depth of 0-30cm; 10cm in diameter) were sampled at monthly interval and taken to the laboratory. Roots, soil, surface litter and detritus were separated by hand and respiratory activity of each component was measured by incubation.

The procedure used measured the contribution of fine roots in the forest ecosystems, while the respiration of coarse roots was calculated according to the power function of specific root respiration depending on root diameter. The mass of coarse roots was taken from literature [*Basilevich,* 1993].

RESULTS AND DISCUSSION

The dynamics of root contribution to the total CO_2 efflux had a seasonal character. In the forest on soddy-podzolic soil (Table 1) the maximal contribution of roots was observed in summer and the share of root respiration in winter was negligibly low. The partitioning respiration of heterotrophs into components determined the sources of CO_2 efflux from soil surface during the dormant periods of the year and by sub zero soil temperatures. The contribution of soil, i.e. CO_2 emission by the decomposition of soil organic matter, comprised in fall 28% and in winter only 16% (Table 1), while the main CO_2 flux was produced by plant residue (surface litter and detritus) decomposition.

Table 1. Contribution of CO_2 sources as % of total efflux from the surface of soddy-podzolic soil under forest

	Summer	Fall	Winter	Spring
Roots	16	12	1	8
Surface litter	18	49	12	9
Detritus	18	11	71	48
Soil	48	28	16	35

Annual root contribution to the total CO_2 efflux was lower then root respiration during growth season in the most of ecosystems studied and amounted to 10-58% depending on ecosystem type and weather conditions (Table 2). The share of root respiration in forests was near constant value –23-28%. Respiration of coarse roots amounted to 45-50% of total root respiration. In grasslands root contribution comprised 10-37% while in croplands it was in more wide range 13-58%. The contribution of roots was higher for crops with prolonged growth period (winter wheat and corn) than for crops with short growth season (spring barley and buckwheat).

Both annual root and microbial respiration was higher in the soil under natural vegetation than under annual crops. Root respiration in croplands amounted to 11-101 gC/m2*yr versus 150-290 gC/m2*yr in forests and 50-247 gC/m2*yr in grasslands. Microbial contribution to the total CO_2 efflux was also higher in natural ecosystems (425-497 gC/m2*yr) in comparison with croplands (64-185 gC/m2*yr). The comparison of root contribution to the total CO_2 efflux from soil in our experiments did not reveal statistically significant difference between natural and agricultural ecosystems.

Table 2. Root contribution to the total CO2 efflux from gray forest and soddy-podzolic soil under forest, grassland and crops

Plant	Treatment	Root contribution, % of efflux	
		annual	seasonal
Gray forest soil			
Maize	Unfertilised	42	49
	NPK+manure	38	50
Winter wheat	Unfertilised	48-58	63-75
	NPK+manure	40-61	52-79
Spring barley	Unfertilised	14-23	19-30
	NPK	14-26	18-34
Buckwheat	Unfertilised	16	33
Sown grassland	Cut, unfertilised	10	28
Secondary forest		23	39
Soddy-podzolic soil			
Grassland	Cut, unfertilised	33	36
Forest		28	30
MEAN	All treatments	33	44

The mean values of root contribution in all ecosystems studied comprised one-third of total annual CO_2 efflux from soil surface (Table 2). This value is lower than 45.8% and 60.4% reported as the world means for the forest and non forest ecosystems respectively [*Hansson et al*, 2000]. The root contribution over growth season is higher (44%, Table2), than annual value, i.e. more close to world mean values. Additionally, a large pool of data reviewed by *Hansson et al* [2000] were measured by root exclusion method. The exclusion of roots removes not only root respiration but also rhizomicrobial respiration and results to the overestimation of root contribution. The comparison of our data with other studies showed that the differences between the results are both ecosystem and methodically inherent and the measurements of root contribution by different methods in one experiment are very urgent.

ACKNOWLEDGMENTS

This research was supported by Presidium of Russian Academy of Sciences and Russian Foundation for Basic Research.

REFERENCES

Bazilevich, N.I. (1993) Biological productivity of Nothern Eurasia ecosystems. Nauka, Moscow (in Russian)

Hansson, P.J., N.T. Edwards, C.T. Garten and J.A. Andrews (2000) Separating root and soil microbial contributions to soil respiration: a review of methods and observations, *Biogeochemistry, 48*, 115

Larionova,A. A., Yermolayev A.M., Blagodatsky S.A., Rozanova L.N., Yevdokimov I.V. and D.B. Orlinsky (1998) Soil respiration and carbon balance of gray forest soils as affected by land use, *Biol Fertil Soils, 27,* 251